Open & shut case

Getting your choice of control valves, actuators and positioners right is key to achieving good process management. Brian Tinham investigates advances

You'll have heard it said more times than you probably care to remember that variance is the bane of manufacturing – and the same is true in the process sector, the utilities and so on. Why? Because it leads to all sorts of problems, ranging from quality issues to yield reductions, rework, excessive energy use, maintenance loading… The list goes on.

Hence the emphasis, in automated process control, on bearing down on the causes of variability – primarily incorrect valve and/or actuator choices, sizing or installation, or poorly tuned or thought-out control loops. Some processes are inherently non-linear – and therefore difficult, however hard engineering works at them – but these are the few. For the rest, control valve, piping and loop stability are as critical today as they have always been.

Which, in 2009, surely shouldn't be a problem? After all, good valve-sizing programs have been available for years, and so-called 'smart' positioners (the devices that respond to the 4–20mA – or digital HART or fieldbus – control signal, driving the booster relays or hydraulics for the valve actuator) make for more forgiving control, don't they? And you get feedback and device diagnostics on top. Also, valve technology has changed little in recent decades, so the subject must be well understood.

All true, to an extent, but there are three important points. First, selecting the right valve remains a skilled job, primarily because of the sheer range of variables – process media, pressure drop, flow requirements, upstream issues, condensing problems, cavitation and flashing potential, noise, required shut-off speed etc (see Plant Engineer May/June 2008, page 12). Second, many of the specialists that used to do this stuff day-in, day-out, are now too thinly spread, so it increasingly falls to plant engineers with a lot more than valves to worry about. And third, control valves and their surrounding paraphernalia have recently been changing more than many realise – to the extent that some of the old rules no longer apply.

Take butterfly valves that have traditionally been limited to, for example, the pulp and paper industry, where pressure and temperature are relatively modest and paper machine manufacturers have gone for lowest cost. Until now, they have seen little use for modulating control in industries such as hydrocarbons, chemicals or pharmaceuticals, partly because those environments are deemed too demanding and partly also because these rotary control valves exhibit an unsuitable fast-opening linear characteristic and only work repeatably in the 25—50% angle opening range.

Why? Because, to date, below 25% opening, a very small change in control signal to the positioner results in a large change in CV (flow coefficient for constant pressure drop). Meanwhile, above 50%, there's a damping effect – not due to the positioner

As simple as valve sizing

Let's tackle one or two myths and misinformation, using the experience of time-served instrument engineer turned valves product manager Tony Harrison, of ARI Armaturen.

"First, too many engineers believe that, if they lose pressure across a valve, they're going to lose performance – for example, downstream on the steam saturation curve. But the fact is, to get accurate control, you need a good pressure drop and, on steam temperature control applications, critical pressure drop is 53%. So your first pointer is that, on steam service, the control valve needs to be smaller than the line size. Second, although globe valves for steam control are designed with an equal percentage characteristic for volume flow against valve plug lift from the seat, at the extremes of their range, that still becomes imperfect. So the ideal is to size your control valve at 85% of the valve capacity for full flow."

Those are the basics for the computer-based, two-port globe control valve sizing programs you'll come across – which also go on to consider valve noise, pipe sizes, process media etc. Things are slightly different, though, when it comes to pressure control applications, where noise and vibration tend to be more problematic. "To manage those problems, valve manufacturers offer a variety of perforated plugs, seat designs and multi-stage trims, and we can also adjust body sizes to achieve most pressure turndown, flow and noise envelopes."

And much the same goes for control valves for incompressible media, such as water, where engineers need to be aware of issues around balancing, with three-port diverter and mixer valves. Best advice: take a look at the main process valve manufacturers' websites.

or any control loop lag, but the butterfly valve itself, which is effectively already almost fully open.

Hence other sectors' historical preference for sliding stem globe valves, which, although expensive (particularly above six inch pipe diameter, because of the quantity of metal and engineering), offer much more reliable full-range modulating capability and present an 'equal percentage' flow characteristic (see Spirax Sarco's website for full explanation). Butterfly valves are used, but only where modulation is less critical and mostly only in manual. And it's a similar story of limited adoption with segment ball valves (also rotary), although the operational control range for these is better at 20–70% of opening and they do exhibit good self-cleaning, due to sediment shearing by the ball.

New butterflies

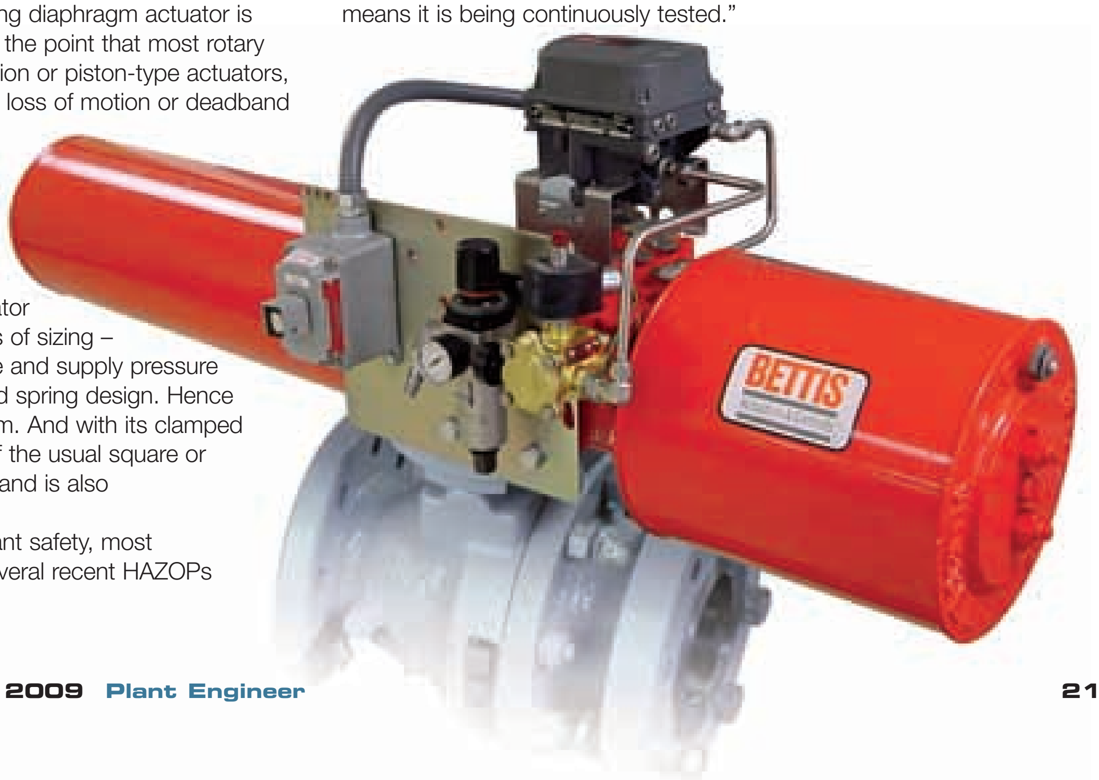
Now, however, a new butterfly valve has emerged from the Emerson Process Management stable that extends the useful operating range to 15—70%. "Fisher's Control-Disk is the best of both worlds," claims Treve Tagg, business unit manager for rotaries at Emerson. "It offers a much wider control range and classic globe valve 'equal percentage' characteristic, but with much smaller flange-to-flange dimensions and much lower cost. What's more, with our spring diaphragm actuator and digital positioner, you're looking at half per cent accuracy and repeatability. And that's just as good if you use a conventional analogue positioner, although the characteristic reverts to linear."

Once word gets out, Tagg expects uptake in all sorts of industries, particularly for retrofitting against existing rotary manual valves in problem loops on, for example, reactor or heat exchanger cooling water applications. "There'll be no requirement for piping modifications, and users can expect stable and automatic control at a fraction of the price."

Incidentally, that spring diaphragm actuator is significant. Tagg makes the point that most rotary valves use rack and pinion or piston-type actuators, which exhibit significant loss of motion or deadband [allowed deviation between demand and actual position], degrading stability to 2–4% or worse. "This valve, however, takes a spring diaphragm actuator without all the problems of sizing – according to spring rate and supply pressure – because of our nested spring design. Hence our 0.5% accuracy claim. And with its clamped splined shaft, instead of the usual square or double 'd' shaft, deadband is also eliminated."

Changing tack to plant safety, most engineers know that several recent HAZOPs have been throwing up an increased requirement for safety control valves on safety loops – the classic being reclassification of risk from SIL 2 to SIL 3. Andrew Evans, product manager with Emerson's Fisher valves brand, reminds us that these will already have a safety on-off valve, as well as a modulating control valve, but that the requirement then rises to a second safety on-off valve.

"Instead of adding another valve, the modern approach is to go for safety redundancy on the existing control valve, unless that might be the source of the trip," he explains. "Not only does that save cost, in terms of a new valve, pipe intervention and wiring, but the user will already have an inventory of spares, and the mere fact of modulation means it is being continuously tested."



Pointers

- Choice of control valve depends on process media, pressure drop, upstream issues, flow, condensing problems, cavitation, flashing, noise, shut-off speed and more
- On steam applications, critical pressure drop to look for is 53%
- As a guide, valves need to be sized at 85% of the valve capacity for full flow
- Actuators, too, come in a huge range of sizes, but go for pneumatic, if you need to control pressure

In that vein, Wendy Nancarrow, Emerson's business unit director, suggests that, all too often, on-off safety valves fail for lack of stroking – which can be solved using another Emerson development from around five years ago. Dubbed DVC 6000 SIS, this is designed to partially stoke on-off safety valves to protect the proof testing regime required to maintain any SIL level. "It solves the issue of users only finding a problem when it's too late," she says. "The unit detects 90% of faults, which are often caused by sticking solenoid valves. It monitors a pulsed control signal for a few milliseconds and checks the pressure differential across the solenoid valve before the safety valve itself starts to move."

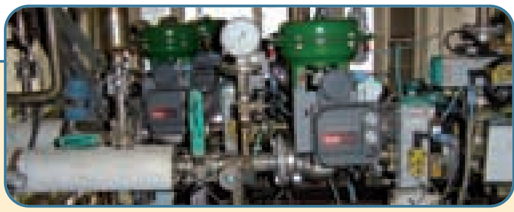
Finally, what about wireless signalling? Wireless fieldbus technology has been around for a couple of years now, with HART 7 on self-organising radio networks looking one of the favourites. Although there is not, as yet, a world standard (so no wireless chipsets from Dust Networks, which controls that market), there have been well-documented process transmitter field trials and, more recently, trials with wireless valve monitoring and control in the power, petrochemical, and oil and gas sectors.

Andrew Guest, instrument business manager for Fisher, advises plant engineers to keep an eye out for its Thum (the HART upgrade module), due out in the next few months. This, he explains, is a wireless antenna unit that screws into any HART instrument, including Emerson's Fieldvue smart valve positioners.

"It hooks up in series with the existing loop wiring on rotary or sliding stem valves [so no need for an additional power source] and it communicates valve position, alerts, alarms and diagnostics via the wireless network," explains Guest. For the thousands of installations where smart positioners have been installed, but aren't being used – because, for example, there's no multiplexer infrastructure on analogue loops – here's a very low-cost and easy way to get deviation feedback, and a lot more, from any intelligent positioner.

As for other benefits, Nancarrow cites remote set-up, commissioning, configuration and valve health monitoring – a big deal on far-flung sites. She also points out that users will be able to recalibrate control valves remotely, from control or instrument rooms, following repair or shutdown. "We believe that, although the power industry has invested heavily in position feedback, less than 10% of other plants are equipped. Now, instead of having to install another costly feedback transmitter and two sets of wires, they will be able to get valuable feedback much more cheaply and easily."

And, again, there's the opportunity to make radical inroads into combating variance. PE



Inside your actuators

Plant engineers need to know that actuators are not all the same – and we're not just talking about thrust rating. Electric actuators, for example, come in two main classifications: S4 and S9 in the IEC 34-1 standard, the former being effectively only available for duty between 25% and 50% of the time, the latter full time.

ABB's Jo Kirkbride explains the differences: "Cheaper S4 units are characterised by the maximum percentage of on-time per cycle and maximum number of cycles per hour. The rest of the time is spent allowing the motor and gear train to cool down. They also have a relatively wide deadband to minimise operating cycles, and some also use thermal de-rating, with sensors adjusting deadband to prevent overheating."

That's fine for less demanding applications but, if you're after fast, precise control, you must specify better – and that's where S9 types (or equivalent) come in. "These are continually energised and are available with deadbands of just 0.05%, even in high ambient temperatures. ABB's Contrac electric actuators also offer faster response, because the motor constantly balances the forces from the process," says Kirkbride.

Yes, they cost more, but you need to understand the value of precision and speed to the process in question. And it's worth knowing that maintenance costs are also generally much lower, mostly because a permanently energised actuator motor design can increase or decrease torque smoothly and proportionally – without the shocks associated with starting and stopping. Further, the use of spur wheel gears in S9 models (as opposed to worm gears in most S4 actuators) reduces mechanical wear.

But this is just the start of another big subject. Tony Harrison, of ARI-Armaturen, makes the point that electric actuators range from simple direct thrust units with poistioner cards, to substantial devices – for example, those used in the power industry on combined heat and power plants with large diesel engines – having 415V three-phase motors and delivering thrusts in the 10s of kN range. Then there are families of spring return electric actuators for failsafe duty – and so on and on.

And then there are all the equivalents in the traditional diaphragm-operated pneumatic actuator ranges, again with spring options, positioners, converters and other accessories to handle every signal, feedback, force and mechanical requirement you're ever likely to come across. "Like all control valve companies, we offer pneumatic-to-pneumatic and current-to-pneumatic converters and positioners that take the control signal [0.2–1bar or 4–20mA], compare it with the valve position and drive the actuator to follow demand by varying high pressure air through an auxiliary valve. We can offer valve position feedback to a PLC or cascade control against another plant parameter feedback loop. We can do that on a single line or move up to digital fieldbus. We can do pretty much anything," says Harrison.

"One word of advice though: if you're controlling pressure, use pneumatic actuators. They respond much faster than electric units. Fully open to closed in one second is easily achieved, compared with up to 40 seconds in electric units," he warns.